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Indian Standard

SHIPBUILDING — DIESEL PROPULSION SYSTEM RESPONSIBILITY — REQUIREMENTS

ICS 47.020.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Price Group 5

Marine Engineering and Safety Aids Sectional Committee, TED 19

FOREWORD

This Indian Standard was adoped by the Bureau of Indian Standards, after the draft finalized by the Marine Engineering and Safety Aids Sectional Committee had been approved by the Transport Engineering Division Council.

This standard has been prepared to specify requirement for propulsion system responsibility for ships with the object to select correct propulsion machineries, to resolve all interfaces between various equipment and to guarantee propulsion system performance requirements.

While preparing this standard due consideration has been given to factors currently followed for matching the propeller with diesel engine.

Failure to meet the propulsion system performance requirement such as speed/thrust of the ship would hamper the roll of the ship originally intended for.

Attention should therefore, be given at the design and selection of machines. Design propulsion system matching should cater at the design stage certain reserve power in diesel engine. To accomplish the same knowledge on propulsion machineries and hydrodynamics of ships should be used. Series of discussions with the equipment suppliers and designers may be required prior to placement of order for the right selection of equipment.

Annex A forms an integral part of this standard.

The composition of the Committee responsible for formulation of this standard is given in Annex B.

Indian Standard

SHIPBUILDING — DIESEL PROPULSION SYSTEM RESPONSIBILITY — REQUIREMENTS

1 SCOPE

1.1 This standard specifies requirement for system responsibility for propulsion plant comprising diesel engine, gear box, stern gear and its control system.

1.2 This standard holds good for diesel engine driven propulsion plant.

2 REFERENCES

2.1 The following Indian Standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
3979 : 1998	Shipbuilding — Testing of marine diesel engines for main propulsion — Code of practice (*first revision*)
10000 (Part 4) : 1980	Methods of tests for internal combustion engines: Part 4 Declaration of power, efficiency, fuel consumption and lubrication oil consumption

3 TERMINOLOGY

3.1 Main Engine

An engine intended for main propulsion.

3.1.1 *Rated Power*

3.1.1.1 *Continuous power*

Continuous power is the net brake power which the engine is capable of delivering continuously, between the normal maintenance intervals stated by the supplier, at the stated speed and under stated ambient conditions prescribed by the supplier being carried out.

3.1.1.2 *Overload power*

Overload power is the net brake power which an engine may be permitted to deliver at standard reference conditions (*see* IS 3979) immediately after working at the continuous power.

The duration and frequency of use of overload power, which is permitted, will depend on service application, but adequate allowance shall be made in setting the engine fuel stop or permit the overload power to be delivered satisfactorily. The overload power shall be expressed as a percentage of continuous power, together with the duration and frequency permitted and the appropriate engine speed.

Unless otherwise stated an overload power of 110 percent of the continuous power at a speed corresponding to engine application is permitted for a period of 1 h without interruptions, within a period of 12 h of operations.

NOTES

1 The power of marine propulsion engine is normally limited to the continuous power so that the overload power cannot be given in service. However, for special applications, marine main propulsion engines may develop overload power in service.

2 If the engine application is not determined the engine supplier shall specify the overload power and corresponding engine speed.

3.1.1.3 *Fuel stop power*

Fuel stop power is the power which an engine is capable of delivering during a stated period corresponding to its application, and at stated speed and under stated ambient conditions, with the fuel limited so that the fuel stop power can not be exceeded.

3.1.1.4 *Intermittent rating*

Engine is rated for specified time at increased engine speed than its continuous power speed for specified application.

3.1.1.5 *Sprint rating*

An engine is rated for a very short duration and rated at slightly higher speed than intermittent speed for specified application.

3.1.1.6 *Service rating*

The rating at which propeller is matched for propulsion maximum continuous operation. Service rating is less than the maximum continuous rating of an engine. This can vary from 85 percent to 90 percent of continuous power at specified speed and depends upon ship owner's/ship designer's requirement.

3.2 Kinds of Statements of Power

3.2.1 *IS Standard Power*

This is the continuous net brake power which the engine manufacturer declares that an engine is capable of delivering continuously, between the normal maintenance intervals stated by the manufacturer, and under the following conditions:

a) At a stated speed under the operating conditions of the engine manufacturer's test bed;
b) With the declared power adjusted to the standard reference conditions as per IS 3979 and tested in accordance with IS 10000 (Part 4); and
c) With the maintenance described by the engine manufacturer being carried out.

3.2.2 *Service Power*

Service power is the power determined under the ambient and operating condition of an engine application.

To establish service power, following conditions shall be taken into account:

a) The ambient conditions, or any nominal ambient conditions according to the special requirements of inspecting and/or legislative authorities and/or classification societies, as specified by the purchaser (*see* Annex A of IS 3979);
   For example, the following nominal ambient conditions apply to main and auxiliary RIC engines on ships for International Association of Classification Societies (IACS) unrestricted service:
   Total barometric pressure $P_X = 100$ kPa
   Air temperature $T_X = 318$ K (45°C)
   Relative humidity $\theta_X = 60$ %
   Sea water temperature (charge air coolant inlet) $T_{CX} = 305$ K (32°C)
b) The nominal duty of the engine;
c) The expected interval between the maintenance periods;
d) The nature and amount of supervision required; and
e) All information relevant to the operation of the engine in service (*see* Annex A and B of IS 3979).

3.3 Flexible Coupling

Flexible coupling is a power transmitting member between the engine and the gear box. Selection/Design of the coupling shall take into consideration such as permissible misalignment, torsional vibration, etc.

3.4 Gear Box

Gear box is a power transmission unit between the engine and the propulsion system. Suitable reverse reduction or reduction gear box chosen for installation between engine and stern gear to match optimum propeller speed with rated speed of engine.

3.5 Stern Gear

Stern gear shall comprise of shafting and propeller.

3.6 Control System

Control system is a device to vary the engine speed, to clutch or de-clutch and/or to vary the pitch of the propeller.

4 SYSTEM RESPONSIBILITY

The system responsibility of a propulsion plant shall be:

a) To select proper engine, gear box, stern gear and control system for the intended application of the vessel;
b) To design the propeller so that under loaded condition of the ship with clean hull and good weather conditions, it can absorb the specified service rating at speed specified in continuous rating;
c) To ensure all machineries and their control system are correctly interfaced;
d) To ensure that selected machinery and control system are installed on-board without any difficulty;
e) To eliminate harmful cavitation to propellers within the entire speed range of propeller operation;
f) To carry out torsional, axial, lateral vibration calculations of entire propulsion system. Input data required for vibration calculations shall be described for all rotating masses. Torsional vibration calculations are required only when the power of the system exceeds 200 kW;
g) To design a shafting system with suitable number of bearings ensuring that no bearing is overloaded in the running condition;
h) To carry out shaft alignment calculations and provide necessary check values to achieve satisfactory alignment on-board; and
j) To guarantee the performance requirement of complete propulsion machinery in terms of their individual equipment operation, and system as a whole as well as to achieve desired sea trial performance to meet shipbuilder's contractual requirements of ship owners.

5 SELECTION OF PROPULSION MACHINERY

5.1 Typical propulsion arrangement is given in Fig. 1.

5.2 Propeller

A device which converts engine torque to thrust. The responsibility of developing the hull lines and the propeller hydrodynamic design fall under ship designer's scope. In the preliminary design stage,

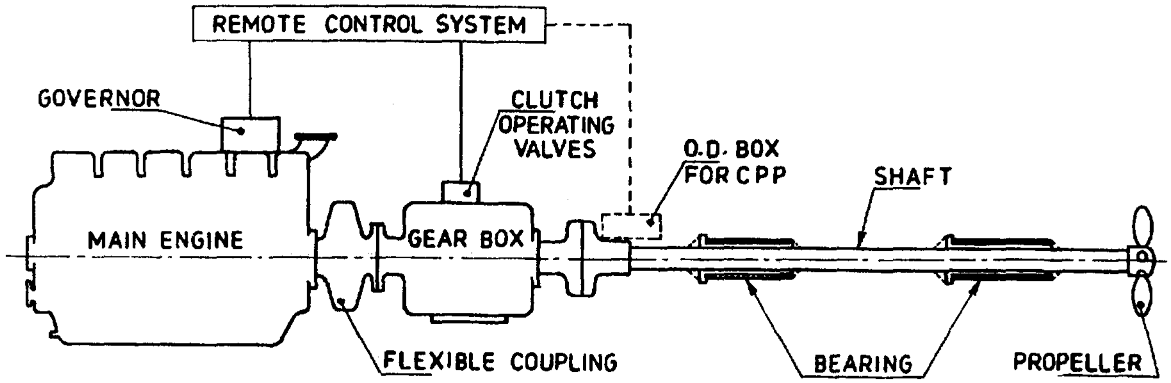

FIG. 1 PROPULSION SYSTEM

most specific information is required in order to make the necessary trade-off studies to support a design selection. Systematic model test report of ship provide the final design of propeller and hull characteristics.

5.3 Engine

The first and most important consideration leading to the selection of a diesel engine is the definition of service requirement. As such it entails obtaining the speed power curves for all important modes of operation such as fully and lightly loaded, clean and fouled bottom, towing and running free and with and without power take-off loads. When the speed power curve has been established an engine can be selected which will develop the required horse power at its appropriate rating.

5.4 Gear Box

Gears are selected to match best propeller rev/min against engine selected with suitable reduction ratio having coaxial or vertical/horizontal offset depends upon shafting/engine room arrangement.

6 POWER FLOW

6.1 Power Effective (P_E)

The power required to tow a ship, at constant speed in unlimited undisturbed water.

6.2 Power Delivered (P_D)

The power delivered to the propeller.

6.3 Power Shaft (P_S)

The power delivered to the shafting system by the propelling machinery.

6.4 Power Brake (P_B)

The power measured at the engine coupling by means of mechanical, hydraulic or electric brake.

6.5 Relationship of P_E, P_D and P_S

$$P_D = \frac{P_E}{n_O \times n_R \times n_H}$$

$$P_S = \frac{P_D}{n_S}$$

$$P_B = \frac{P_S}{n_G} \quad (n_G \text{ is 1 when gear box is not fitted})$$

where

n_H = Hull efficiency,
n_O = Propeller efficiency,
n_R = Relative rotative efficiency,
n_S = Shafting efficiency (not less than 97 percent), and
n_G = Gear box efficiency (not less than 97 percent).

6.6 Generally power demanded by propeller which is considered as delivered horse power (P_D) will be given to propulsion system selector. It can be observed from the power flow characteristic that engine to drive the propeller needs to be selected after accounting for power losses through shafting and gear boxes. The continuous power of engine shall have reserve margin to accomplish service requirements and shall normally include the margins given in **6.6.1**, **6.6.2** and **6.6.3** depending on ship owners'/ship designers' considerations.

P_B thus derived for engine shall be matched with propeller characteristics as given in Fig. 2 at 85 percent to 90 percent continuous power rating for economical fuel consumption.

6.6.1 *Sea Margin*

Power reserve to maintain a given ships speed allowing for weather, sea force, aging and fouling of hull as well as roughening of propeller blades.

6.6.2 *Operational Margin*

Mechanical and thermodynamic power reserve for economical operation of engine (for low fuel and maintenance costs).

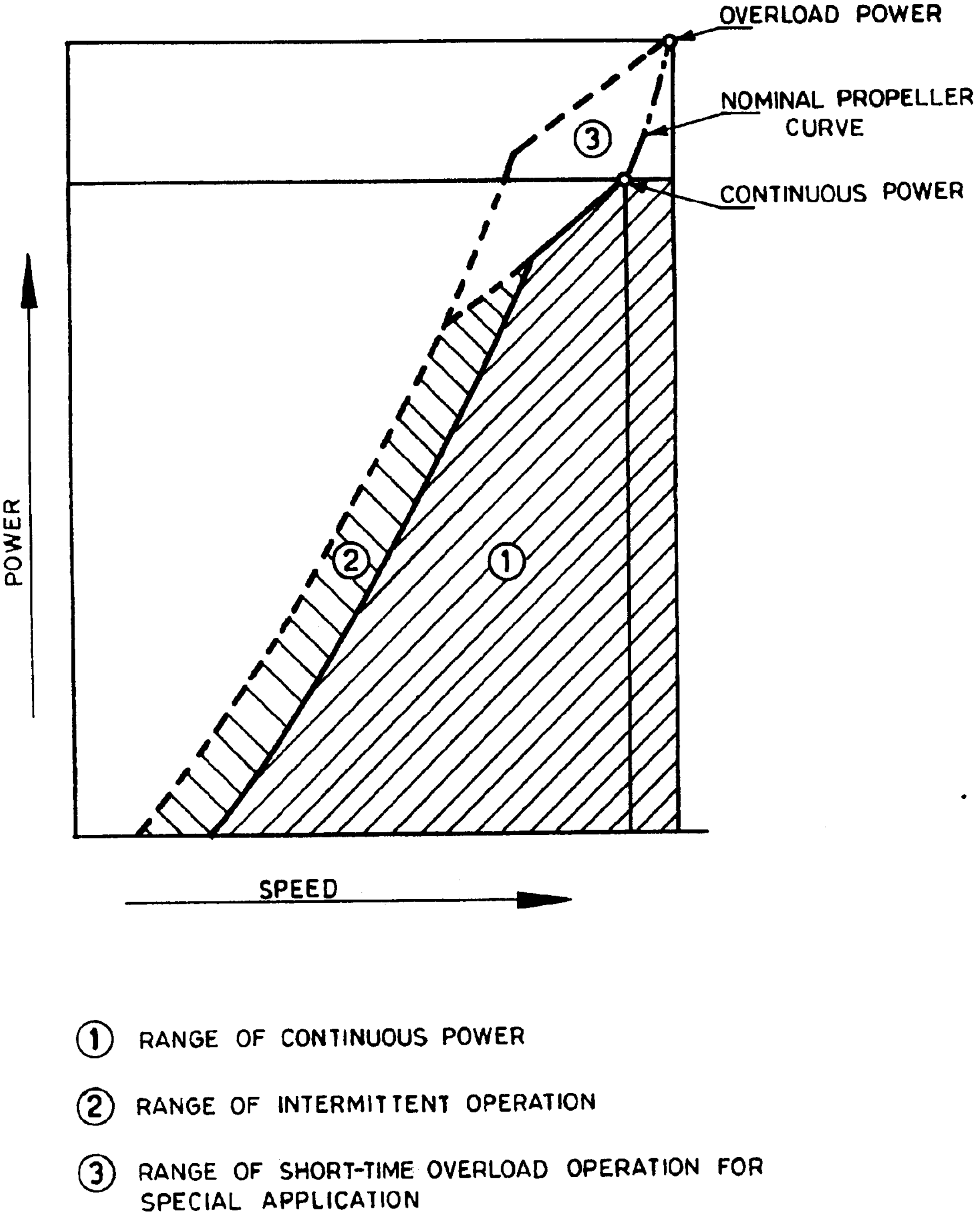
OVERLOAD POWER
NOMINAL PROPELLER CURVE
CONTINUOUS POWER
③
②
①
POWER
SPEED
① RANGE OF CONTINUOUS POWER
② RANGE OF INTERMITTENT OPERATION
③ RANGE OF SHORT-TIME OVERLOAD OPERATION FOR SPECIAL APPLICATION

FIG. 2 EXAMPLE FOR A POWER/SPEED DIAGRAM

6.6.3 *RPM Margin*

Margin in propeller revolutions with new ship (that is under sea trial condition) to attain or maintain any power up to continuous power in future continuous service.

7 MODEL TEST/DRAWINGS REQUIRED FOR SELECTION AND INSTALLATION OF PROPULSION SYSTEM

7.1 The total propulsion plant shall be selected in such a way that the machineries are installed comfortably within the space allocated in machinery room and shall perform to meet contractual requirements. To assess the performance following need to be scrutinised by those who give system responsibility:

a) Hull lines of the ship;
b) Model test report if any with respect to propulsion test carried out;
c) Ship's bottom structure in way of propulsion machineries;
d) 'A' or 'P' bracket details;
e) Engine characteristics;
f) Propeller characteristics;
g) Stern gear arrangement;
h) Installation drawing for main engine and gear box; and
j) Layout of engine room, machinery control room, wheel house and general arrangement of the ship.

8 INTERFACE

If propulsion machinery and its control system are required to be interfaced satisfactorily, then there should be a flow information broadly as indicated in Annex A.

9 MANUFACTURING AND TESTING

Main engine, gear box, stern gear (shafting system), thrust block and remote control system are to be manufactured and tested wherever applicable in accordance with rules, regulations and National/International Standards as specified by the purchaser.

10 ON-BOARD TEST

During the sea trial, by means of torsion meter check the shaft horse power which is delivered to the propeller and by means of thrust meter (if available) check thrust produced by the propeller.

11 WARRANTY

Propulsion system responsibility when assured shall warrant that delivered horse power (DHP) as sought by the ship designer shall be delivered to the propeller. In the event that requisite DHP is not achieved as noted from torsion meter or the propeller even after receiving the requisite DHP is unable to produce the requisite thrust to move the ship as per contractual speed requirement, the subject need to be discussed mutually.

ANNEX A

(Clause 8)

INTERFACE DATA

Sl No.	Information Required	Main Engine	Gear Box	Stern Gear	Remote Control System	Shipbuilder
1.	Main engine	—	1. Idle and maximum engine speed 2. Torque at idle and maximum engine speed 3. Flexible coupling output flange details	1. Engine characteristics	1. Details of control gear provided on the engine 2. Details of safety arrangement provided on the engine 3. Instrumentation chart indicating minimum and maximum set values and operating range, circuitory 4. Wiring diagram 5. Characteristics of following against speed — Pressure — Temperature — Fuel rack — Power 6. Engine characteristics indicating idle and maximum speed 7. Engine start/stop sequence logic 8. Engine control safety and monitoring circuit 9. Documentation for sensors fitted 10. Details for start interlock safeties, shut down condition clutch block and safeties de-clutching condition 11. Engine overload details	1. Installation drawings in 1:20 or 1:25 scales to make shipbuilder structural drawings, clearly indicating following: — Drawings in three views — Centre of gravity and weight — Holding down arrangement (loose, fitted bolts information and their arrangement, approx. design calculation , etc) — Engine end connections 2. Engine associated drawings clearly giving for — Bill of materials identifying engine and yard scope — All loose accessories drawings with end connection details. 3. Guidance drawing for engine seating 4. Recommended pipe line diagrams (for fresh water, oil, compressed air, fuel oil, etc) 5. Recommended lubricating oil grades, volume of fresh water, lubricating oil, etc in main engine system 6. Recommended heat balance diagram 7. Crankshaft flange details 8. Guidance drawings for lateral supports, thrust brackets 9. Details of unbalanced forces/moments on engine 10. Maximum values of shear force/bending moments at crankshaft flange for shaft alignment purposes 11. Recommended capacities for pumps/coolers/compressors/air receivers/ engine room crane, etc
2.	Gear box	1. Break away torque 2. Clutch engagement speed	—	1. Output coupling flange details 2. Driven shaft along with its bearings details	1. Details of control gear provided on the gear box 2. Safety arrangement if any catered	1. Installation drawing in 1:20 or 1:25 scale to make shipbuilder structural drawings clearly indicating the following:

Sl No.	Information Required	Main Engine	Gear Box	Stern Gear	Remote Control System	Shipbuilder
		3. Technical data to carry out torsional vibration analysis.		3. Thermal expansion value of bearings 4. Maximum permissible bearing load	3. Instrumentation chart indicating minimum and maximum set values and operating range 4. Documentation for sensors fitted	— Drawings in three views — CG and weight — Holding down arrangement (loose, fitted, bolts information and their arrangement calculation) 2. Gearbox associated drawings clearly giving details for: — Bill of materials identifying gear box — All loose accessories drawings with end connection details 3. Thurst bearing details 4. Recommend GAP, SAG Value of GB output flange to shaft flange 5. Line diagram for piping on gear box 6. Cocking arrangement of gear box 7. Details of pumps/coolers provided on gear box 8. Sea water quantity requirement for heat exchanger 9. Weight of main gear wheel, moments of inertia of gear wheels for torsional vibration calculations
3.	Stern gear	1. Propeller characteristics 2. Technical data required for torsional vibration characteristics 3. FOR CPP PROPELLERS 3.1 Pitch changing time 3.2 Combinator curve 3.3 Numerical value of engine BP corresponding to pitch angle	1. Stern gear shaft flange to be coupled to output flange of gearbox 2. Shaft lock, brake disc 3. Shaft load on GB bearings as the result of shaft alignment calculations FOR CPP PROPELLERS 1. CPP OD Box details 2. CPP pump if any to be driven by gear box	—	For fixed pitch propeller-nil FOR CPP PROPELLERS 1. Combinator curve 2. Pitch changing time 3. Details of interlock, safeties shut down conditions	1. Details of stern gear assembly drawing 2. Details of shaft bearings, seals, etc 3. Propeller characteristics matching with recommended service rating of engine after allowing 6 percent losses on shafting system 4. KT/KQ diagram 5. Cavitation analysis 6. Axial, lateral vibration calculations 7. Shaft alignment calculation and procedure 8. For CPP besides above 8.1 Pitch-speed power curve 8.2 Combinator curve 9. Individual drawings for following items to be furnished indicating weights: a) Propeller shaft b) Intermediate shaft c) Coupling bolts d) Bushes e) Seals f) Propeller (indicating dia/pitch/blade area/moment of inertia) g) Propeller cap h) Recommended lubricating oil diagram

Sl No.	Information Required	Main Engine	Gear Box	Stern Gear	Remote Control System	Shipbuilder
						j) Shaft bearings (indicating clearances, sea water requirement, etc)
4.	Remote control system	Control, safeties, monitoring scheme for engine supplier approval concurrence	Control safety monitoring scheme for GB supplier approval	FOR CPP SYSTEM ONLY Control, safety monitoring scheme for stern gear approval	—	1. Control, safeties monitoring scheme 2. GA and details of control panel 3. Pneumatic/wiring diagram 4. Details of special cables, cable connections, etc. 5. Individual drawings for different types of valves and components provided in the control systems indicating their functions
5	Shipbuilder	All shipbuilders drawings asscoiated with main engine for engine supplier concurrence	All shipbuilders drawings associated with gear box for gear box supplier concurrence	Structural arrangement of stern gear	Shipbuilder wiring/ piping scheme	—

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Marine Engineering and Safety Aids Sectional Committee, TED 19

Organization	*Representative(s)*
DG Shipping, Mumbai	SHRI B. K. BISWAS (***Chairman***)
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Central Institute of Fisheries Technology, Cochin	DR T. K. SIVASAD
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